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(54) **SHAPED MEMORY DEVICES AND METHOD FOR USING SAME IN WELLBORES**

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E21B 29/10 (2006.01)

(52) **U.S. Cl.**
CPC ***E21B 43/12*** (2013.01); ***E21B 29/10*** (2013.01)

(58) **Field of Classification Search**
CPC E21B 33/12
See application file for complete search history.

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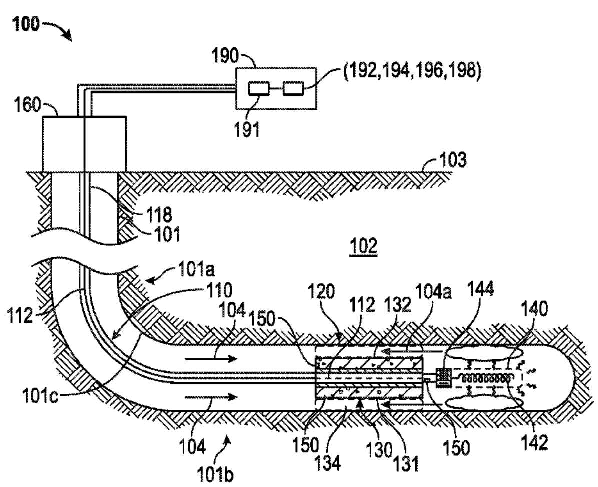
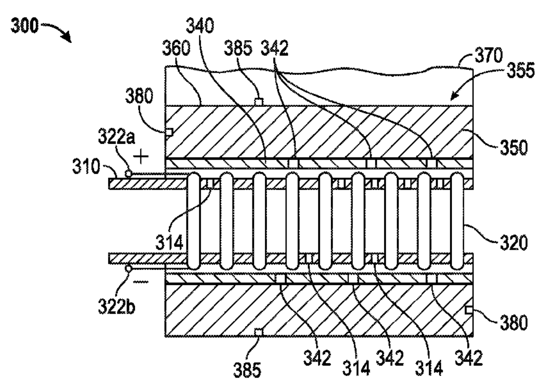
(57) **ABSTRACT**

In one aspect an apparatus for use in a wellbore is disclosed that in one embodiment includes a device or tool conveyable in the wellbore, wherein the device or tool further includes a shape memory member formed into a compressed state, the shape memory device having a glass transition temperature and a heating device associated with the shape memory member configured to heat in the wellbore the shape memory member to or above the glass transition temperature to expand the shape memory member to a second expanded state.

20 Claims, 2 Drawing Sheets





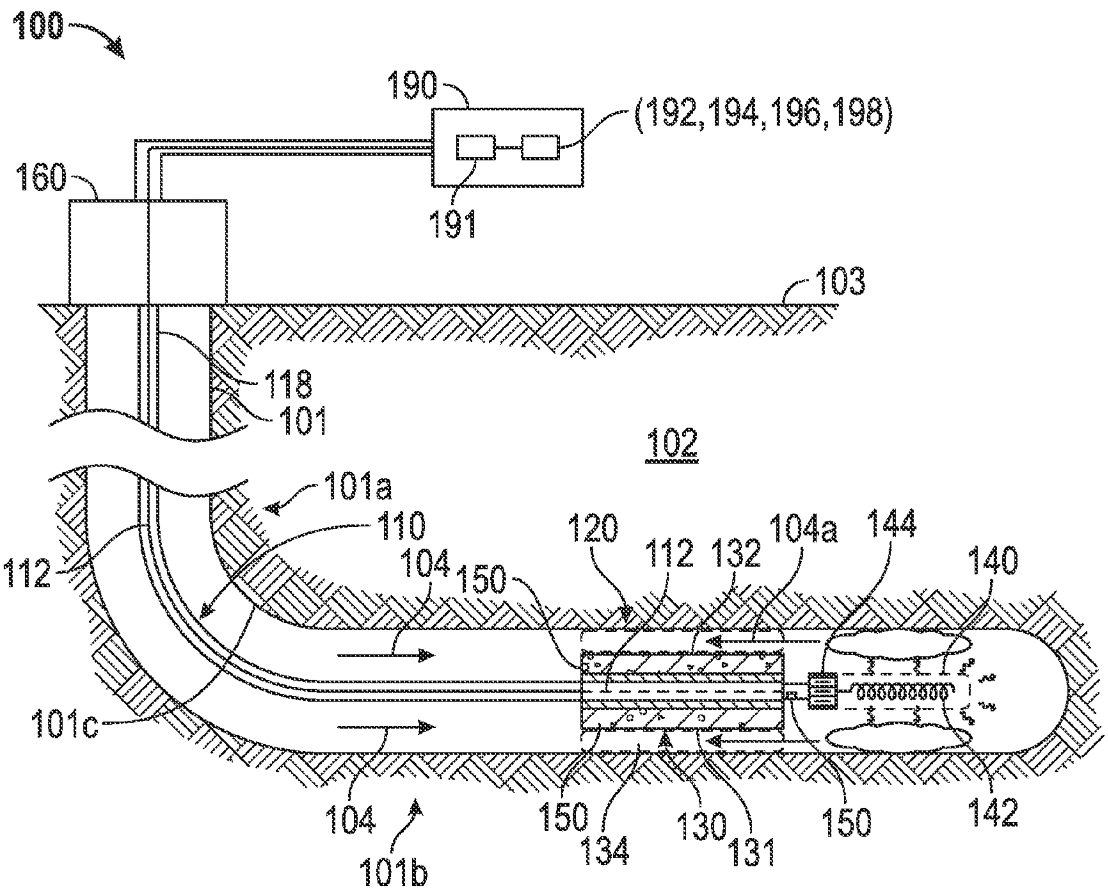

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FIG. 1

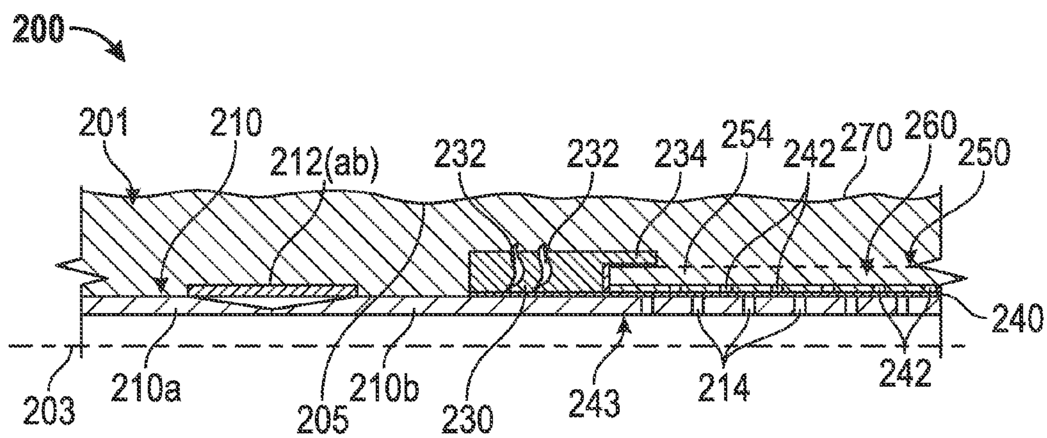
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FIG. 2

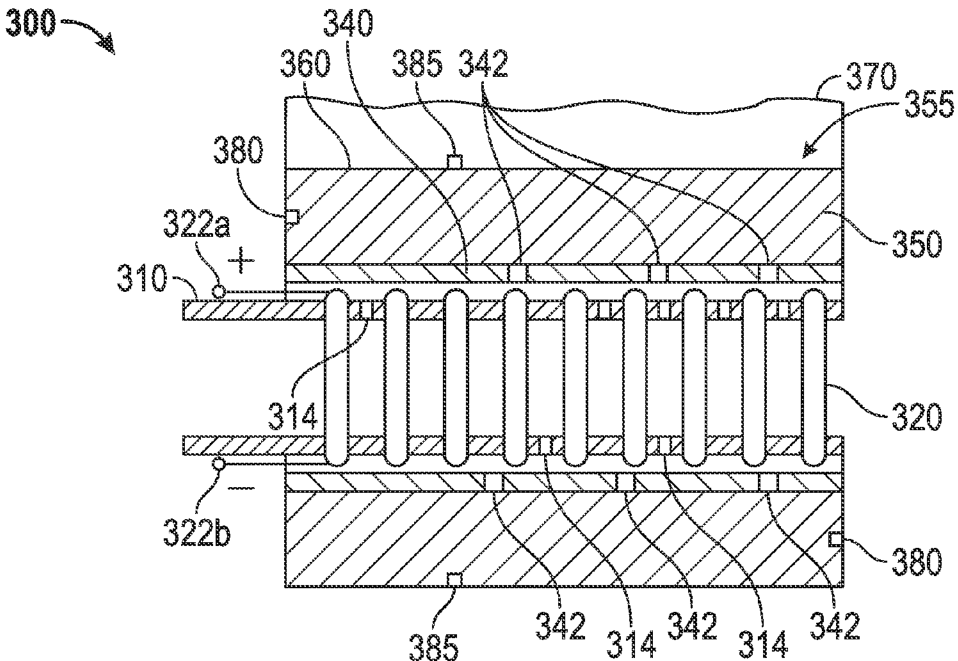

FIG. 3

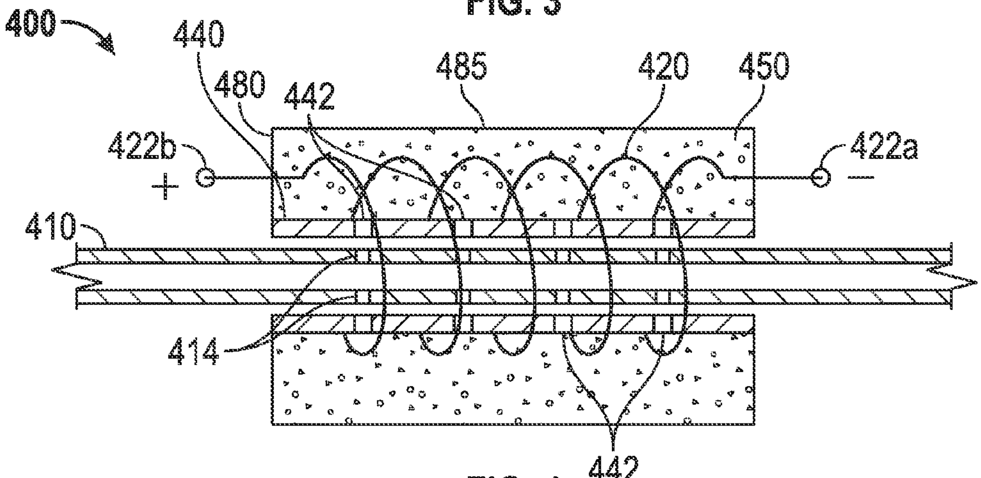

FIG. 4

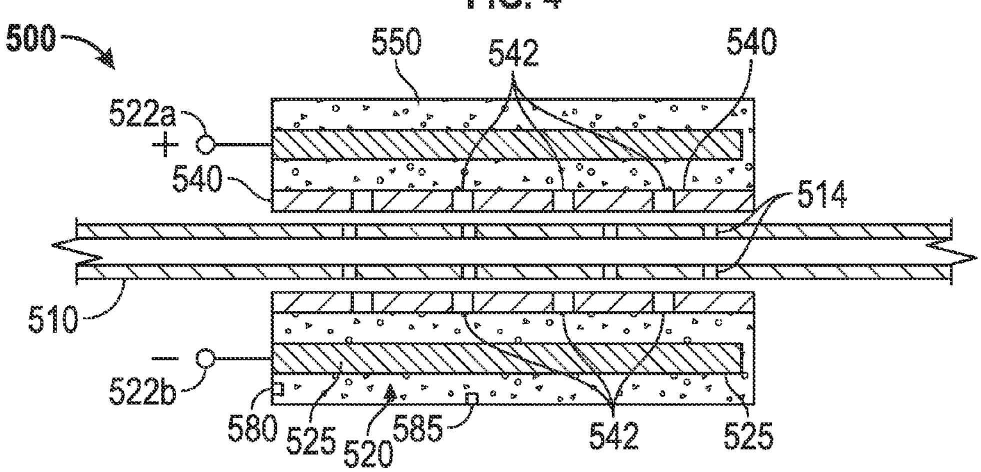

FIG. 5

SHAPED MEMORY DEVICES AND METHOD FOR USING SAME IN WELLBORES

BACKGROUND

1. Field of the Disclosure

The disclosure relates generally to apparatus and methods for installing shape memory devices in wellbores.

2. Description of the Related Art

Hydrocarbons, such as oil and gas, are recovered from subterranean formations using a well or wellbore drilled into such formations. In some cases the wellbore is completed by placing a casing along the wellbore length and perforating the casing adjacent each production zone (hydrocarbon bearing zone) to extract fluids (such as oil and gas) from such a production zone. In other cases, the wellbore may be an open hole, which may be used to produce hydrocarbons or inject steam or other substances into a geological formation. One or more flow control devices are placed in the wellbore to control the flow of fluids from the formation into the wellbore. These flow control devices and production zones are generally fluidly isolated or separated from each other by installing a packer between them. Other devices also are utilized to temporarily plug sections of a wellbore or to control flow of fluids through the wellbore or a production string deployed to convey formation fluid to the surface. Certain devices having shape memory materials (shape memory devices) have been disclosed and utilized in wellbores for such purposes. A shape memory material can be heated to or above its glass transition temperature to attain a selected or desired expanded shape or state and then compressed to desired compressed shape to retain it in such compressed shape at temperatures below the glass transition temperature. When the shape material is again heated to or above its glass transition temperature, it expands to the expanded shape. For wellbore applications, a shape memory material or member, which may be a part of a device or tool, is typically formed in a compressed state and then deployed in the wellbore. The wellbores typically contain a fluid, such as a drilling or another fluid and are often at a temperature above the glass transition temperature of the shape memory material. The shape memory device deployed in the wellbore heats over time and attains the expanded shape. However, in certain wells, the temperature is not sufficiently high to heat the shape memory device above its glass transition temperature or the heating process may take a relatively long time to cause the shape memory device to expand. It is thus desirable to have devices in the wellbore to controllably heat the shape memory devices in the wellbore to cause the shape memory materials to attain their expanded shapes.

The present disclosure provides shape memory devices and systems for controllably heating and setting such shape memory device in wellbores.

SUMMARY

In one aspect an apparatus for use in a wellbore is disclosed that in one embodiment includes a downhole tool or device conveyable in the wellbore, wherein the downhole tool or device further includes a shape memory member in a compressed shape or state, the shape memory member having a glass transition temperature and a heating device configured to heat in the wellbore the shape memory member to or above the glass transition temperature to expand the shape memory member to an expanded shape or state.

In another aspect, a method of providing an apparatus for use in a wellbore is disclosed that in one embodiment may include: providing a device having a shape memory member in a compressed state; placing a heating element proximate or in the shape memory member; and providing a source that supplies electrical energy to the heating element to heat the shape memory to an expanded state.

Examples of some features of the disclosure have been summarized rather broadly in order that detailed description thereof that follows may be better understood, and in order that some of the contributions to the art may be appreciated. There are, of course, additional features of the disclosure that will be described hereinafter and which will form the subject of the claims appended hereto.

BRIEF DESCRIPTION OF THE DRAWINGS

The advantages and further aspects of the disclosure will be readily appreciated by those of ordinary skill in the art as the same becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings, in which like reference characters generally designate like or similar elements throughout the several figures, and wherein:

FIG. **1** is a schematic elevation view of an exemplary wellbore system wherein a work string containing a shape memory device made according to one embodiment of the disclosure is deployed in a wellbore;

FIG. **2** shows a sectional side view of a shape memory device made according to one embodiment the disclosure and placed on a base pipe in a wellbore;

FIG. **3** shows shape memory device made according to another embodiment of the disclosure that includes a heating element installed on a base pipe, such as the base pipe shown in FIG. **3**;

FIG. **4** shows a shape memory device that includes a coil embedded in the shape memory material to heat such material, according to yet other embodiment of the disclosure; and

FIG. **5** shows a shape memory device that includes one or more heat strips or rods embedded in the shape memory material to heat such material, according to yet another embodiment of the disclosure.

DETAILED DESCRIPTION OF THE DISCLOSURE

The present disclosure relates to devices and methods for controlling production of hydrocarbons in wellbores. The present disclosure is susceptible to embodiments of different forms. There are shown in the drawings, and herein described, specific embodiments of the present disclosure with the understanding that the present disclosure is to be considered an exemplification of the principles of the devices and methods described herein and is not intended to limit the disclosure to the specific embodiments. Also, the feature or a combination of features should not be construed as essential unless expressly stated as essential.

FIG. **1** shows an exemplary wellbore system **100** that includes a wellbore **101** drilled through an earth formation **102** from a surface location **103** for producing hydrocarbons from the formation **102**. The wellbore **101** is shown as an open hole, i.e., without any casing therein. The wellbore **101** is shown to include a vertical section **101***a* and a deviated or substantially horizontal section **101***b*. The wellbore system **100** includes a work string **110** that includes a downhole assembly **120** conveyed in the wellbore **101** by a conveying member **118**, such as a wireline or a coiled tubing. The wellbore system **100** further includes a wellhead unit **160** through which the conveying member **118** and the downhole assembly **120** are deployed into the wellbore **101**. The wellbore **101** is further shown to contain a fluid **104**, such as a drilling fluid.

Still referring to FIG. **1**, the downhole assembly **120**, in one aspect, includes a shape memory device **130**, which device is desired to be placed or installed in the wellbore. In aspects, the shape memory device **130** may include a suitable shape memory material or member known in the art. A shape memory member or material, for the purpose of this disclosure, is a material device that may be heated to or above its glass transition temperature to an expanded shape and then compressed to a compressed shape and cooled to retain the compressed shape until reheated to or above its glass transition temperature to case it to attain its expanded shape. Shape memory materials are known in the art and are thus not described in detail herein. Any suitable shape memory, however, included, but not limited to polymers, may be utilized. The shape memory device **130** is shown conveyed and placed in the wellbore **101** at a location where it is desired to be expanded and set. The particular shape memory device **130** has outer dimensions **131** when it is in the compressed state. The device **130** when heated to or above the glass transition temperature of its shape memory material will expand to contact and press against the wellbore wall **101***c* and attain the expanded shape as shown by dimensions **134**.

The downhole assembly **120** further includes a heating device **140** that includes a heating element **142** and a source **144** for supplying electric energy or power to the heating element **142**. The heating element may be made in the form of a coil, metallic strips or may have any other form known in the art. In one aspect, the electric energy source may be a battery **144** electrically coupled to the heating element **142** placed in the downhole assembly **130**. In one aspect, the heating element may be placed downhole or below the shape memory device **130**, whereas the battery **144** may be placed either uphole (above) or downhole of the shape memory device **130**. In another aspect, the heating device **140** may be removably mounted in the downhole assembly **120**, such that after setting or expanding the shape memory device **130** in the wellbore, the heating element **142** and the battery **144** may be retrieved to the surface **103**. In another aspect, the electrical energy to the heating element **142** may be supplied from a surface source **191** via an electrical line **112** running through the conveying member **118**. One or more temperature sensors, such as sensors **150**, may be placed at suitable locations in the downhole assembly **120** to provide temperature measurements proximate the shape memory device **130**.

Still referring to FIG. **1**, the system **100** further includes a surface unit **190**, which may be a computer-based system that may further include electrical circuits **192** to pre-process sensor signals, a processor **194**, such as a microprocessor, one or more storage devices **196**, such as memory devices, and programs **198** that include instructions accessible to the processor **192** for executing such instructions.

After setting or placing the downhole assembly **120** at the desired location in the wellbore **101**, the control unit **190** may cause the electric energy source **144** or **191** at the surface to supply electrical energy to the heating element **142**. When the heating element is heated, the fluid **104** proximate the heating element is heated, which fluid causes the shape memory member to heat. The controller **190** determines the temperature of the fluid from the signals provided by the temperature sensor **150** and may control the supply of the electrical energy to the heating element **142** and thus the temperature of the heating element to cause the temperature of the shape memory member to rise to or above the glass transition temperature of the shape memory member. After the shape memory member has attained the desired expanded state or after a selected time period, the controller **190** may stop supplying the electrical energy to the heating element **142** (i.e., deactivate the heating element). The conveying member **118** may then be dislodged from the shape memory at a connection point **136** and retrieved to the surface **103** with the heating element **142** and the battery **144**. In other aspects, the heating element and the battery may not be detachable element and thus may be left in the wellbore **101**.

FIG. **2** shows a sectional side view of a shape memory device **200** made according to one embodiment of the disclosure and placed around a base pipe or tubing **210** having an axis **203**. The base pipe **210**, which may extend from a surface location into the wellbore, may be formed by axially joining base pipe sections, such as sections **210***a*, **210***b*, etc. Adjoining base pipe sections, such as **210***a* and **210***b*, may be joined by any suitable mechanical connection, such as a connector **212***ab* known in the art. The base pipe **210** includes a number of fluid passages **214** over a selected base pipe length to allow flow of fluid from the formation into the base pipe. In the particular embodiment of FIG. **2**, the exemplary shape memory device **200** is shown as a packer, but it may be made into any other suitable shape or form according to the principles described herein. The shape memory device **200** includes a shape memory member (also sometimes referred to as an element or a material) **250** surrounding a tubular **240**, which tubular may be made from any suitable material, such as steel or another suitable alloy. The tubular **240** includes a number of fluid passages **242** that allow a fluid passing through the shape memory element **250** to pass into the base pipe **210**. The shape memory member **250** is shown in the compressed state having outer dimensions **260**. The tubular **240** may include any number of fluid passages **242** to enable a fluid to pass from outside of the shape memory member **250** to inside **243** of the tubular **240**. In one aspect, ends, such as end **254** of the shape memory device **200** may be securely inserted into a side pocket **234** of a centralizer **230** to form a unified assembly. The unified assembly may then be inserted over the base pipe **210** and secured thereon by suitable attachments, such as screws **232**. The shape memory member or element **250**, when heated in the wellbore by a device made according to an embodiment or principles described herein, will expand to attain an expanded shape **270** and press against inside **205** of the wellbore **201**. The shape memory device **200** further includes a heating element as described in reference to FIG. **1** or FIGS. **3-5** described below.

FIG. **3** shows a shape memory device **300** made according to another embodiment of the disclosure. FIG. **3** shows a base pipe **310** having a number of perforations of fluid passages **314**. A heating element **320**, such as a coil, may be wrapped around the base pipe **310** about the fluid passages **314**. Alternatively, the heating element may be formed in the form of metallic strips and placed on the base pipe **310**. Electric energy to the heating element **320** may be supplied from an energy source, such as a battery or a source at the surface **191**, via terminals **322***a* and **222***b*, as described in reference to FIG. **1**. The shape memory device **300** further includes a shape memory member or material **350** placed around a tubular member **340** having perforations or fluid passages **342**. The combination of the tubular **340** and the shape memory member **350** may be formed as unitary member or device **355** that can be placed or slipped over the heating element **320**. In such a configuration, the shape memory device **300** includes a heating element **320** placed on the base pipe **310** and a unitary device **355** that includes the shape memory material **350** on a tubular **340**. The unitary member **355** is placed on the heating element **320** in a compressed state or shape **360** and conveyed into the wellbore to a selected depth. When electrical energy is supplied to the heating element **320**, i.e., when the heating element **350** is activated, such as by the surface control unit **190**, FIG. **1**, or a timing device downhole, heat conducts from the heating element **320** to the tubular **340**, which heats the shape memory material **350** to or above its glass transition temperature. The shape memory material **350** then expands from its compressed state or shape **360** to an expanded state or shape **370** and presses against the wellbore wall. Temperature sensors **380** placed at one or more suitable locations on or proximate the shape memory device may be utilized to control the electrical energy and timing thereof to controllably activate the shape memory device in the wellbore. Additionally, one or more pressure sensors **385** may be provided to determine pressure applied by the shape memory device on another element, such as wellbore wall to determine the adequacy of the contact between the shape memory device **300** and the wellbore wall. In aspects, the control unit **190** may determine the temperature from temperature sensors **180** and/or pressure from the pressure sensors and control heating of the shape memory member **350**.

FIG. **4** shows a shape memory device **400** made according to yet another embodiment of the disclosure. The shape memory device **400** is shown placed around fluid passages **414** in a base pipe **410**. In one aspect, the shape memory device **400** includes a shape memory member or material **450** placed or attached around a tubular **440** having fluid flow passages **442**. A heating element **420** is embedded or partially embedded in the shape memory material **450** during manufacturing of the shape memory device **400**. The electrical energy to the heating element **420** may be supplied via terminals **422***a* and **422***b*, as described in reference to FIGS. **1** and **3**. Additionally temperature sensors **480** and pressure sensors **485** may be placed in or proximate to the shape memory device **400** and utilized by the controller **190** to control the heating of the heating element **420**, as described in reference to FIG. **1**.

FIG. **5** shows a shape memory device **500** made according to yet another embodiment of the disclosure. The shape memory device **500** is shown placed around fluid passages **514** in a base pipe **510**. In one aspect, the shape memory device **500** includes a shape memory member or material **550** placed around or attached around to a tubular **540** having fluid flow passages **542**. A heating element **520** containing one or more conductive strips **525** may be embedded or partially embedded in the shape memory material **550** during manufacturing of the shape memory device **500**. The electrical energy to the heating element **520** may be supplied via terminals **522***a* and **522***b*, as described in reference to FIG. **1**. Additionally, temperature sensors **580** and pressure sensors **585** may be placed in or proximate to the shape memory device **500** and utilized by the controller **190** to control the heating of the heating element **520**, as described in reference to FIG. **1**.

It should be understood that FIGS. **1-5** are intended to be merely illustrative of the teachings of the principles and methods described herein and which principles and methods may applied to design, construct and/or utilizes inflow control devices. Furthermore, foregoing description is directed to particular embodiments of the present disclosure for the purpose of illustration and explanation. It will be apparent, however, to one skilled in the art that many modifications and changes to the embodiment set forth above are possible without departing from the scope of the disclosure.

The invention claimed is:

1. An apparatus for use in a wellbore, comprising:

a downhole tool conveyable in the wellbore, the downhole tool comprising:

a fluid passage in the downhole tool for allowing fluid outside the downhole tool to pass into the downhole tool;

a shape memory member formed into a first compressed state over the fluid passage in the downhole tool, the shape memory device having a glass transition temperature; and

a heating device associated with the shape memory member configured to heat in the wellbore the shape memory member to or above the glass transition temperature to expand the shape memory member to a second expanded state;

wherein fluid passing from outside the downhole tool into the downhole tool via the fluid passage passes through the shape memory member.

2. The apparatus of claim **1** further comprising a conveying member attached to the downhole tool for conveying the downhole tool into the wellbore.

3. The apparatus of claim **1**, wherein the heating device includes a heating element and a power source for activating the heating element.

4. The apparatus of claim **3**, wherein the power source is selected from a group consisting of: a battery in the downhole tool; and a power line in the conveying member that supplies electrical energy from a surface location to the heating element.

5. The apparatus of claim **1** further comprising a sensor for providing signals relating to a parameter of interest relating to expansion of the shape memory member in the wellbore.

6. The apparatus of claim **5**, wherein the parameter of interest is selected from a group consisting of: temperature; and pressure.

7. The apparatus of claim **5** further comprising a controller that receives signals from the sensor and in response thereto controls heating of the shape memory member.

8. The apparatus of claim **1**, wherein the heating device includes a heating element that is selected from a group consisting of: a heating element downhole and uphole of the shape memory member configured to heat a fluid in the wellbore proximate to the shape memory member to a selected temperature; a heating element at least partially embedded in the shape memory member; and a heating element placed on a tubing inside the shape memory member.

9. The apparatus of claim **1**, wherein the heating device includes a heating element selected from the group consisting of: a coil placed around a tubular associated with the shape memory member; a coil at least partially embedded inside a shape memory member; a heat conducting strip placed on a tubular associated with the shape memory member; and a heat conducting strip at least partially embedded inside the shape memory member.

10. A work string disposed in a wellbore, comprising:

a conveying member conveyed from a surface location into the wellbore;

a tool coupled to the conveying member and placed at a selected location in the wellbore, the tool comprising:

a fluid passage for allowing fluid to pass from outside the tool to inside the tool;

a shape memory member placed over the fluid passage that expands from a compressed shape to an expanded shape when the shape memory member is heated to a selected temperature, wherein the fluid passing through the fluid passage from outside the tool to inside the tool passes through the shape memory member; and

a heating device that heats the shape memory member to the selected temperature.

11. The work string of claim **10**, wherein the shape memory member is formed on a metallic tubular disposed outside of a tubing associated with the conveying member.

12. The work string of claim **10**, wherein the heating device is selected from a group consisting of: a coil placed around a tubular associated with the shape memory member; a coil at least partially embedded inside a shape memory member; a heat conducting strip placed on a tubular associated with the shape memory member; and a heat conducting strip at least partially embedded inside the shape memory member.

13. The work string of claim **10** further comprising a power source for supplying electrical energy to the heating element.

14. A device for use in a wellbore, comprising:

a base pipe having a fluid flow passage;

a shape memory member placed around the base pipe and over the fluid flow passage that expands from a compressed shape to an expanded shape when the shape memory member is heated to a selected temperature;

a heating element placed proximate or in the shape memory member that heats the shape memory member to the selected temperature; and

a source proximate or embedded in the shape memory member that supplies electrical energy to the heating element to heat the shape memory member to or above a glass transition temperature of the shape memory member;

wherein fluid from outside the base pipe passes through the shape memory member to pass through the fluid flow passage into the base pipe.

15. A method of providing an apparatus for use in a wellbore, comprising:

providing a metallic tubular including a fluid passage;

providing a shape memory member in a compressed state on the metallic tubular and over the fluid passage to form a downhole assembly, wherein the fluid passage allows fluid outside the metallic tubular to pass into the metallic tubular through the shape memory member;

placing a heating element proximate or in the shape memory member; and

providing a source that supplies electrical energy to the heating element to heat the shape memory member to a selected temperature.

16. The method of claim **15**, wherein providing the heating element comprises placing the heating element at a location selected from a group consisting of: downhole of the shape memory member; uphole of the shape memory member; at least partially inside the shape memory member; and on a metallic member placed within an opening in the shape memory member.

17. The method of claim **15**, wherein providing the heating element comprises providing a heating element selected from a group consisting of: a coil placed around a metallic member proximate the shape memory member; a strip placed on a metallic member proximate to the shape memory member; a coil at least partially embedded in the shape memory member; a strip at least partially embedded inside the shape memory member; and heat element downhole of the shape memory member.

18. The method of claim **15** further comprising conveying the downhole assembly in the wellbore.

19. The method of claim **18** further comprising supplying electrical energy to the heating element to heat the heating element to a selected temperature for a selected time period cause the shape memory member to expand from the compressed state.

20. A method of producing fluid from a wellbore formed in a formation, comprising:

providing a work string containing a tool conveying member and a tool attached thereto, the tool including:

a fluid passage in the tool allowing fluid outside the tool to pass into the tool;

a shape memory member in a compressed state placed over the fluid passage,

a heating element configured to heat the shape memory member when the shape memory member is in the wellbore, and

conveying the work string into the wellbore and locating the tool at a selected location in the wellbore;

supplying electrical energy to the heating element to heat the shape memory member for a selected time period to expand the shape memory member from the compressed state; and

producing the fluid from the wellbore by passing the fluid through the expanded shape memory member, through the fluid passage and into the tool.

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